



Energy Efficiency and Conservation

Americans consume about 15 percent of the world's energy, but we make up roughly four percent of the world's population. The average American consumes just under four times the world average per capita consumption of energy. Keeping our buildings comfortable, moving ourselves around, and powering all of our appliances and electronics don't just cost a lot of money. They take a toll on the environment.

Making the Case for Saving Energy

More than 80 percent of the world's energy comes from fossil fuels. Burning fossil fuels releases carbon dioxide (CO₂) into the atmosphere. The buildup of CO₂ and other greenhouse gases is the primary cause of the climate change occurring today. As temperatures rise and extreme weather events become more common, energy demands for heating and cooling are also rising. Improving energy efficiency and reducing unnecessary energy consumption conserves resources, lowers energy costs, and reduces greenhouse gas emissions.

Energy Efficiency

Energy efficiency refers to the amount of energy a device uses when operating. Some refrigerators use less energy than others, but all keep food cold. A large truck with a big engine and a small car with a smaller engine will both get you to the store, but the truck uses more fuel to do it. Energy efficiency means choosing devices that use less energy.

Professionals trying to save energy evaluate the heating, ventilation, and air conditioning (HVAC) system, the lighting, and the other devices that are top energy consumers, such as water heaters and refrigerators. Replacing an existing device for one that is more efficient is known as an upgrade. When deciding on an upgrade, compare the amount of energy saved to the cost.

Energy Conservation

Conserving a resource does not mean we can never use it. Conservation involves using the resource wisely so it lasts as long as possible.

Energy conservation means we are changing our behavior to use less energy and use it wisely.

There are times when replacing something with a more efficient model is not possible. That does not mean saving energy is impossible. Small changes in things we do can often reduce energy consumption by 10 to 15 percent, and sometimes as much as 30 percent.

Building Envelope

All buildings, from the tiniest of tiny homes to the largest of factories, have an envelope. Like a paper envelope surrounds documents, a building envelope surrounds the things we want to keep separate from the outdoor environment. A building envelope keeps us and our stuff warm, dry, and protected. Walls, windows, doors, the roof, and flooring are all parts of the building envelope.

A building envelope keeps the inside at a comfortable temperature with insulation. Different **insulation** materials, like fiberglass and expandable foam, have different properties. Some are better insulators than others. Insulation is described by its **R-value**. This is a number that tells you how well the insulation blocks the movement of heat. A higher R-value material is a better insulator.

Insulation R-Values

TYPE OF INSULATION	R-VALUE (PER INCH)
Cellulose, loose fill	3.7
Cellulose, high density	3.2
Fiberglass batt	3.0
Foam board	7.0



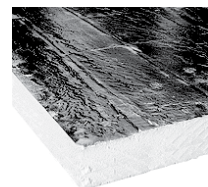
3.0
Fiberglass Batt



3.7
Cellulose, Loose Fill



3.2
Cellulose, High Density



7.0
Foam Board

Openings in the building envelope are called breaks. Besides windows and doors, breaks include openings that allow electricity, water lines, and other connections inside. Without breaks, the building envelope would just be a closed, dark box that nobody could go into. This would not be very practical. All breaks need to be sealed well to keep outside air from getting inside, or inside air from getting out. Air moving through a break in the building envelope is called **air infiltration**. **Caulking** is used around window and door frames. **Weatherstripping** is used inside the frames to make sure they are sealed well when closed. Openings for electrical, water, and cooling lines are usually sealed with foam so air and insects cannot get in. A hidden source of air infiltration is often the box in the wall where switches and electric outlets are connected. Foam gaskets can be put around the switch and outlet behind the cover to block air from moving through these boxes.

Replacing caulking and weatherstripping and adding gaskets to switch and outlet boxes are relatively simple actions that can save a lot of energy. Many utility companies offer weatherization services at no charge to residential customers. Programs and rebates for commercial customers may also be available.

Building Envelope Tips

Follow these tips to reduce energy consumption in buildings:

- Keep windows and doors closed when the heating or cooling system is turned on.
- Check around exterior doors—daylight means outdoor air is getting in.
- Make sure windows open and close without sticking, and are sealed well.
- Check the insulation in the attic space and add more where necessary.
- Install insulating gaskets behind outlet and switch covers.

HVAC Systems

Heating, ventilation, and air conditioning systems use a machine to warm or cool air and send it out to different parts of a room or building. **Ventilation** is usually only used in commercial or industrial buildings. Commercial buildings have more people inside them than homes typically would have, and industrial buildings have a lot of machinery. Fresh air must be brought into these buildings to keep everyone healthy and alert.

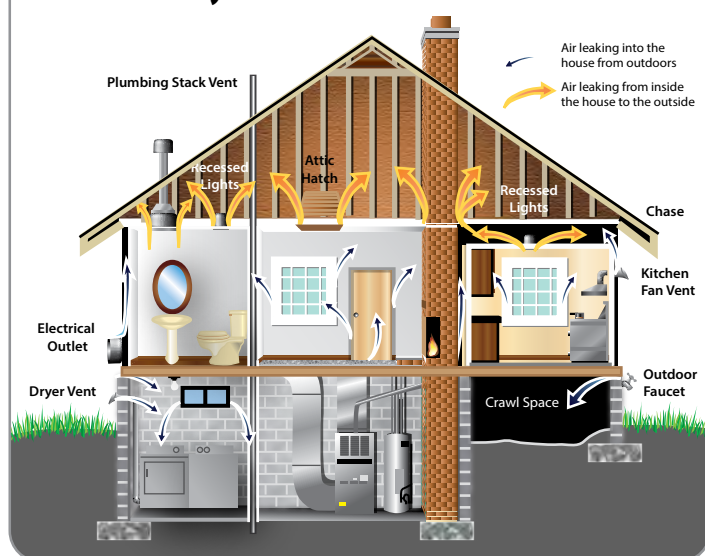
The two biggest energy-wasting concerns with HVAC systems are **ducts** that have leaks and thermostats set too high. Ducts are metal tubes in the walls, ceiling, or floor that deliver warmed or cooled air. If the duct work is leaking, the system needs to work harder to push more air through it. Rooms farther from the furnace will be hot in summer and cold in winter. Sealing the leaks with the proper tape fixes this problem. Setting the thermostat to a very warm temperature in winter or a very cool temperature in summer uses a lot of energy. The U.S. Department of Energy suggests a winter heating temperature of 68° and a summer cooling temperature of 77° to save the most energy. Wearing a sweater in winter or using a fan in summer and not bumping the thermostat will help save energy.

HVAC System Tips

Follow these tips to reduce energy consumption when heating or cooling:

- In winter, set the thermostat to 68°F or lower. Wear a sweater if you are chilly.
- In summer, set the thermostat to 77°F or warmer. Use a fan if you are too warm.
- Regularly change the air filter.
- Use duct sealing tape to block any leaks in duct work.
- Make sure duct work running through attics or crawl spaces is insulated.
- Open blinds or curtains in winter to allow sunlight to warm the room. Close them in summer to prevent this.

House as a System



THERMOSTAT



Image courtesy of Adobe Stock

Lighting

Commercial buildings use much more lighting than residential or industrial buildings, but all three types of buildings have some kind of indoor lighting. The most efficient lights are LED lights, though many schools and other commercial buildings still rely on fluorescent lights.

The two biggest energy wasters when using lighting are lights that are too bright for the task, and lights that are left on unnecessarily. The Illuminating Engineering Society of North America has developed a list of recommended light levels, measured in **foot-candles**, for rooms based on the activities happening there. A foot-candle is the amount of light from one candle that reaches a surface located one foot away from the candle. Different tasks require different amounts of light. For example, school cafeterias should have about 20-30 foot-candles of illuminance, but a laboratory-style classroom needs 50-75.

Unlike school, we all tend to use many different kinds of light fixtures at home. Overhead lights help us see the entire room. Desk and table lamps give us light where we need it. Small lamps and other lit accessories give us soft lighting while watching TV or navigating at night. It would not make sense to have all of these turned on at once. Choose the light that best fits what you are going to do and leave the rest turned off.

Modern technology has given us lighting controls that automatically turn lights on and off, and even adjust how bright they are. Motion sensors turn lights on when someone enters the room. Occupancy sensors turn lights off when no movement is detected after a certain time period. Dimmer switches allow the user to make lights brighter or dimmer and only produce the amount of light they need. All of these help save energy. However, manually turning the lights off instead of waiting for an occupancy sensor to do it saves even more energy.

The least expensive, best energy-saving lighting is daylight. Opening blinds or curtains to take advantage of free daylight can save up to 100 percent of the energy used if you keep all of the lights turned off! However, it is important to balance using daylight against the cooling system's energy use. Opening the blinds or curtains to allow sunlight in can warm the room, which works against the room's cooling system. Consider all energy users, not just lighting, when deciding to open the blinds or curtains.

LIGHT SHELF

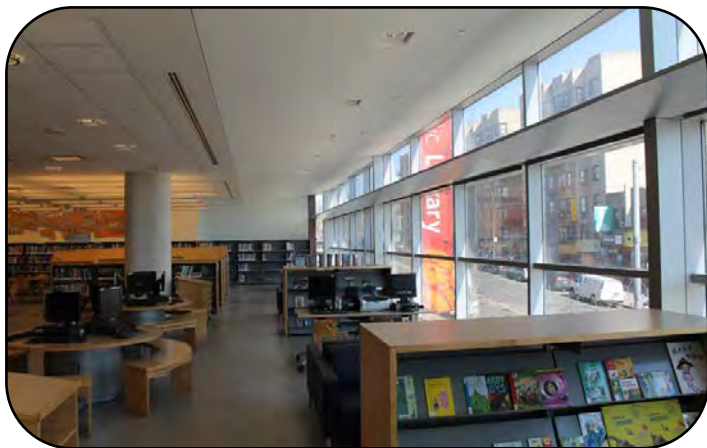


Image courtesy of Wikimedia Commons

The second floor of the Bronx Library in New York has a light shelf that redirects daylight further into the building.

DIMMER SWITCH



Image courtesy of Adobe Stock

Lighting Tips

Follow these tips to reduce energy used for artificial lighting:

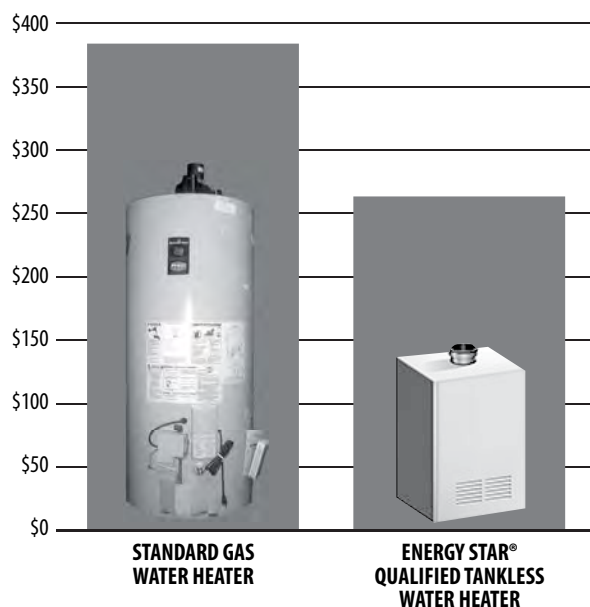
- Do not overlight spaces. At home, only turn on the lights you need. Use light bulbs or light fixtures that provide the right amount of light.
- Do not leave lights on when a room is empty. Turning them off saves 100 percent of the energy the lights were using.
- Install LED light bulbs or light fixtures to get the brightest light using the least amount of electricity (but don't overlight!).
- Use daylight through windows and skylights instead of turning lights on.

Water Heating

The energy to heat water is not something we think about until we do not have it. Heating water takes a lot of energy. Different energy-saving strategies are used in residential and commercial buildings because the way hot water is used in each environment is different.

Water Heater Comparison

ANNUAL ENERGY COSTS PER YEAR



Data: ENERGY STAR®

Any commercial building with a kitchen, like a school or restaurant, needs to provide very hot water for the kitchen—160°F! Dishes, cookware, and utensils must be cleaned and sanitized, which requires hotter water than most homes use. Industrial processes might need water at near-boiling, as high as 200°F or more. Industrial and commercial buildings have water heating equipment that is much larger and uses significantly more energy than residential equipment. When you are at school, you can help use less energy by not leaving hot water running unnecessarily.

Most homes have a water heater with a tank that keeps the water at a set temperature. Adding an insulating jacket to the water heater keeps thermal energy from being transferred to the area around the water heater, and insulating the pipe carrying the hot water to the fixtures using it helps, too.

Tankless water heaters are now available that only turn on when hot water is needed. When operating, they use a large amount of energy, but if no hot water is needed, they do not run at all. Most of the time, a tankless system uses less energy than a residential system with a tank.

Water should not be heated above 120°F, especially with young children in the home. Water that is hotter than necessary uses more energy and can cause serious burns.

Water Heating Tips

Follow these tips to reduce energy used for heating water:

- Take showers instead of baths. Showers use significantly less water.
- Set the water heater so it delivers water at 120°F. If you are going to be away from home for an extended period of time, turn it to its lowest setting—often “vacation” or “pilot.” Remember to turn it up when you get back home.
- Wash clothes in cold water. Modern detergents are formulated for cold water washing.
- Fill a sink or wash basin with soapy water to wash dishes, then rinse them all at once or in batches. Do not let the hot water run while washing dishes.
- Install an insulating jacket around the water heater and make sure pipes delivering hot water are also insulated.

Plug Loads

A load is anything being powered by electricity. A plug load is anything that plugs into an outlet and uses electricity. Appliances, electronics, lamps, fans, and your gaming system are all plug loads. In short, if it plugs in, it's a plug load! The way these devices are used varies greatly, but there are some strategies that apply to all of them that we can use to save energy. The first is probably the most obvious: Don't allow something to run if it's not necessary. Another way to save energy is to purchase items that use less energy while operating.

Plug Load Tips

Follow these tips to reduce energy consumed by appliances and electronics:

REFRIGERATORS

- Make sure the gasket around the door seals completely. If a piece of paper or dollar bill can easily slide out from behind it, replace it.
- Do not allow the door to stay open longer than necessary. Help organize the groceries in groups to minimize the amount of time it takes to put them away. Close the door while you pour a beverage.
- Fill empty milk jugs or soda bottles with water and use them to fill empty spaces in the back of the refrigerator.
- Keep the area around and under the refrigerator clear and dust-free so the compressor operates at its best.
- Empty and unplug second refrigerators. Only plug in and operate when absolutely necessary.

WASHING MACHINES

- Set the washing machine appropriately for what you are washing. Aim for a full load of laundry when possible, as it will save water and energy.
- Use cold water for washing.

CLOTHES DRYERS

- Clean the lint filter after every load. Encourage or assist the adults in your home to make sure lint is cleaned from the interior of the dryer and dryer duct.
- Use the lowest heat setting possible.
- Hang clothes to dry outside when possible and use free solar energy.

DISHWASHERS

- Turn off the heated dry and allow dishes to air-dry. Opening the door when the cycle is complete will help.
- Run the dishwasher with the proper cycle or settings for the load size and dirt level of the dishes. Most modern dishwashers will use less water than hand-washing, even for smaller loads, if settings are chosen correctly.

TELEVISIONS, AUDIO AND GAMING SYSTEMS, AND RELATED DEVICES

- Plug devices into a smart strip surge protector that senses when the TV or primary device is off and cuts power to other items plugged into it. It also has the option for keeping some items, like a cable box, powered all the time.
- Use energy-saving settings and sleep timers to reduce electricity when possible.

OFFICE EQUIPMENT

- Power down devices when they are not being used for extended periods of time.
- Disable screen savers, as they use more electricity than sleep mode.
- Keep printers and scanners off until they are needed.
- Power down monitors when devices are off. Monitors that remain on will waste electricity.

EnergyGuide and ENERGY STAR®

Most appliances sold in the United States have a yellow-and-black EnergyGuide label. The label estimates how much energy an appliance uses and its approximate yearly operating cost. This information helps consumers compare similar products. Some products also qualify for the ENERGY STAR® label. ENERGY STAR® appliances and electronics use less energy than many similar products. Although energy-efficient products sometimes cost more to purchase, they often cost less to operate over time. Consumers sometimes compare the purchase price of an appliance to the money it may save on energy costs. The amount of time required for the savings to equal the additional purchase cost is called the payback period.

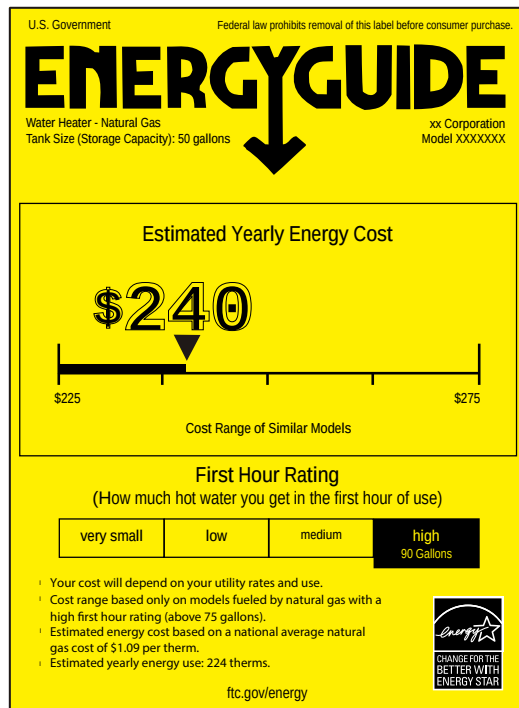
Purchasing energy-efficient appliances is one way to reduce energy use, but it is not the only way. Simple changes in how we use appliances and electronics can also save energy.

ENERGY STAR® Logo

Energy-efficient products are labeled with the ENERGY STAR® logo. Appliances include the EnergyGuide label allowing for easy energy comparisons between products.



EnergyGuide Label



Appliance Energy Consumption

Appliance	Average annual expenditure	kWh/yr
Electric stove, oven or range	\$38	290
Ceiling fan	\$29	226
Clothes dryer	\$87	680
Clothes washer	\$9	69
Dishwasher	\$15	112
Microwaves	\$15	107
Refrigerator	\$87	617
Second freezer	\$74	632
TV and related components	\$87	760

Data: EIA 2020 RECS

*Average yearly consumption data accounts for devices used in different modes, i.e., idle, charging, etc.

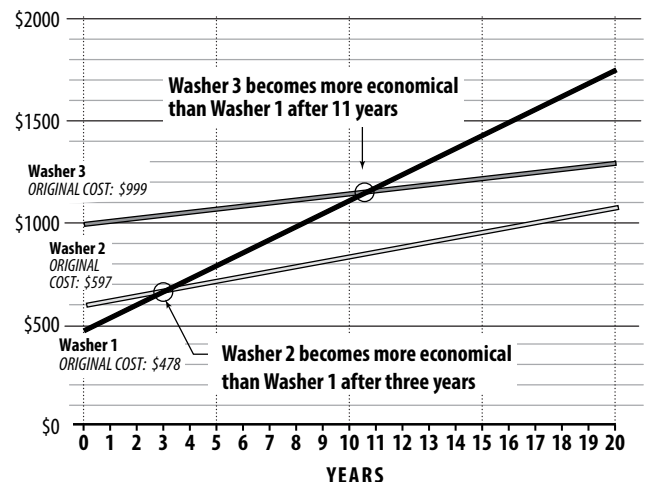
Washing Machine Payback Period

Spending a little bit more money on an energy-efficient appliance could save you several hundred dollars over the lifetime of the product. The payback period could be shorter than you think!



	WASHER 1	WASHER 2	WASHER 3
Original Cost	\$478	\$597	\$999
Estimated Annual Electricity Use	427 kWh	160 kWh	102 kWh
Price of Electricity (per kWh)	\$0.15	\$0.15	\$0.15
Operating Cost per Year	\$64.05	\$24.00	\$15.30

COST OVER THE LIFETIME OF THE MACHINE



Data: NEED analysis of washing machine EnergyGuide labels

Energy and Electricity

Electricity generation is the biggest energy consumer out of any other use. In 2025, three-fourths of electricity was generated with energy sources that heat water into steam. Thermal power plants are only about 30 percent efficient, meaning much of the energy is lost as waste heat and cannot be used to generate electricity. Saving electricity doesn't just make financial sense, it is environmentally smart, too. The cleanest and cheapest unit of energy is the one that never needs to be produced.

Phantom Loads

Some devices are always using power—even when they are turned off! This constant trickle of energy use is called a phantom load or a vampire load. How can you tell if something has a phantom load? Any device with a clock, LED, indicator light, or remote control, has a phantom load. There are plug-in meters that show phantom loads. Using a power strip or physically unplugging the device when not in use will stop the phantom load drain. Single-serving hot beverage machines can have some of the highest phantom loads because they are designed to keep water hot and ready for use.

MICROWAVE—A PHANTOM LOAD



Image courtesy of Adobe Stock

Transportation

Moving people and goods from one place to another uses a lot of energy. Passenger vehicles like cars and SUVs run on gasoline, and larger vehicles use diesel fuel. Ships and planes use fuels specifically made for those engines. Almost all of these fuels are petroleum products. Petroleum is expensive, and using it for energy produces carbon dioxide.

The transportation sector produces more carbon dioxide than any other sector—almost one-third of CO₂ emissions in 2025. When adults purchase vehicles, fuel efficiency is one factor they may consider. Keeping the vehicle maintained well and using good driving habits keep energy consumption down.

Even though, as a student, you cannot control the size, age, or fuel efficiency of the vehicles that move you and the products you use around, there are some things you can do to save energy with transportation.

Transportation Tips

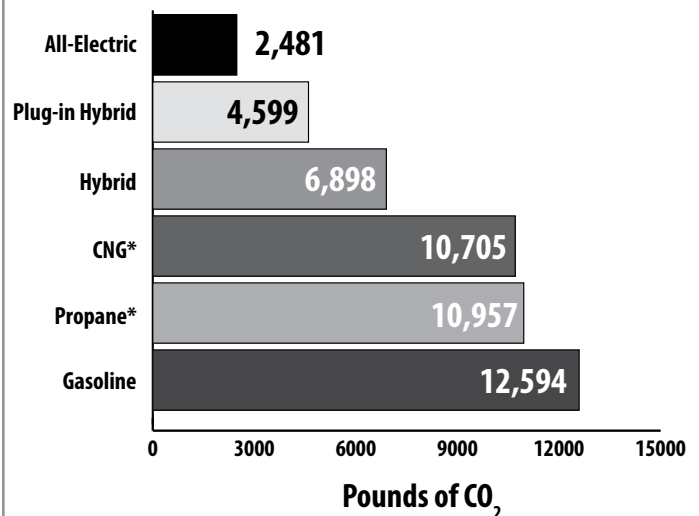
Follow these tips to reduce the amount of energy for transportation you use:

- Carpool with others going the same place as you.
- Take public transportation.
- Walk or ride your bike.
- Combine errands into one longer trip.
- When shopping online, choose shipping options that combine items into fewer deliveries.

Carbon Emissions

New technologies allow vehicles to use less fuel and produce less CO₂ emissions. Some vehicles use alternative fuels such as compressed natural gas (CNG) or propane. These vehicles are often owned by private companies or city governments. Hybrid vehicles combine a gasoline engine and an electric motor. Electric vehicles use batteries and electric motors instead of gasoline engines. These vehicles usually produce less CO₂ than gasoline-powered vehicles.

U.S. CO₂ Emissions per Vehicle, 2024



*Calculated based on estimate from Argonne National Laboratory
Data Source: Alternative Fuels Data Center

Materials and Manufacturing

Saving energy in industry is not achieved only at the manufacturing site. Consumers have the ability to greatly reduce the energy consumed for making materials and products. Beyond the energy consumed just to make materials like steel, aluminum, and paper is the energy needed to transport the products and dispose of the waste. Disposable, single-use items are one of the biggest consumers of energy in the realm of materials and manufacturing. Industry leaders are working on adopting improved technology and recovering waste heat from processes to reduce the energy their facilities consume.